Division of Research and Laboratory Services

THE APPLIED SCIENCES BRANCH

FUNCTION AND CAPABILITIES

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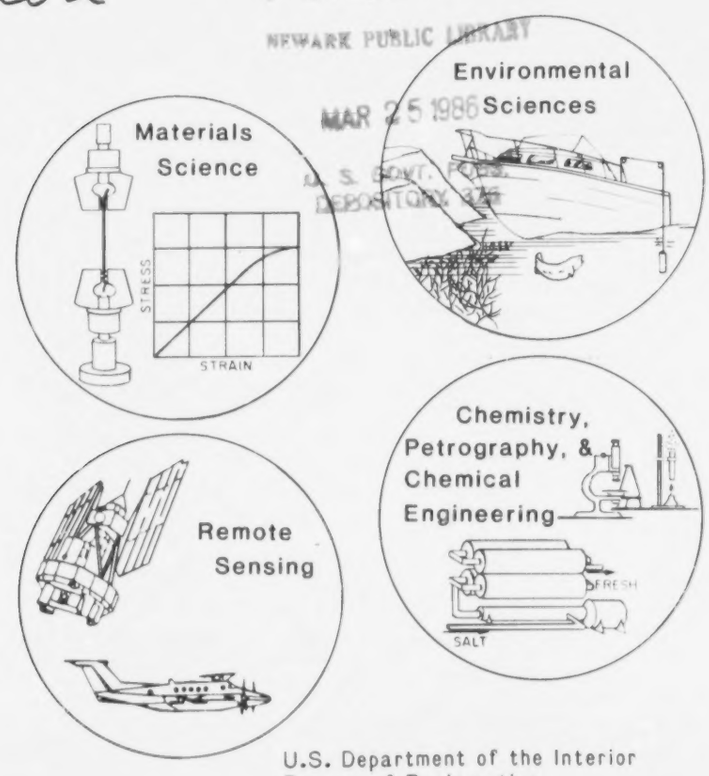

U.S. Department of the Interior
Bureau of Reclamation
Engineering and Research Center
Denver, Colorado

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Mission of the Bureau of Reclamation

The Bureau of Reclamation of the U.S. Department of the Interior is responsible for the development and conservation of the Nation's water resources in the Western United States.

The Bureau's original purpose "to provide for the reclamation of arid and semiarid lands in the West" today covers a wide range of interrelated functions. These include providing municipal and industrial water supplies; hydroelectric power generation; irrigation water for agriculture; water quality improvement; flood control; river navigation; river regulation and control; fish and wildlife enhancement; outdoor recreation; and research on water-related design, construction, materials, atmospheric management, and wind and solar power.

Bureau programs most frequently are the result of close cooperation with the U.S. Congress, other Federal agencies, States, local governments, academic institutions, water-user organizations, and other concerned groups.

I. INTRODUCTION

The Applied Sciences Branch of the Division of Research conducts a variety of scientific and technical investigations to provide information for many Bureau of Reclamation applications. These investigations include activities such as determining the chemical and physical properties of engineering materials; studying the effects of construction and operation of project facilities on the water quality, ecology, and fisheries of lakes, rivers, and canals; conducting studies to determine the use and effects of herbicides, and biological and mechanical techniques to control weeds on irrigation projects; and chemically analyzing such substances as water, cement, paint, soils, and crops.

The Branch was formed in 1970, from a merger of the Chemical Engineering Branch and the Water Conservation Branch. As its name suggests, the Applied Sciences Branch provides expertise in disciplines different from those commonly associated with traditional water resource development. These disciplines are represented by the four sections that make up the Branch: the Environmental Sciences Section; the Chemistry, Petrography, and Chemical Engineering Section; the Materials Science Section; and the Remote Sensing Section. Each of these sections is responsible for several specialized functions. They perform research, sometimes in conjunction with other branches, Government agencies, and international organizations, to provide the Bureau and the engineering community with valuable information to support the development of water resources.

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II. THE ENVIRONMENTAL SCIENCES SECTION

A. Function

The Environmental Sciences Section studies the interrelationship between the environment and Bureau projects. Research programs conducted by section personnel contribute to the effectiveness and efficiency of water development projects by providing information to reduce or minimize harm to the environment.

The Section is composed of two groups. The Aquatic Ecology Research Group studies the impact of Bureau projects on the aquatic environment. It investigates the effects of dams, powerplants, and other manmade facilities on the ecology of reservoirs, lakes, and streams; on water quality; on reservoir recreation; and on other significant aspects of the environment.

The Environmental Sciences Section studies include evaluation and study of microscopic plants and animals, aquatic weeds, and insects that live in streams, lakes, and reservoirs.

The Aquatic Site Pest Control Research Group has responsibility for developing and evaluating environmentally safe methods for controlling pests in and around aquatic sites. These pests include algae, aquatic and terrestrial weeds, invertebrate animals, such as freshwater clams and aquatic insects; and burrowing animals in and around hydraulic structures.

B. Facilities and Capabilities

The Environmental Sciences Section is staffed by biologists and engineers with expertise in aquatic ecology, aquatic botany, plant physiology, fishery science, biochemistry, herbicide residue analysis, and other environmental disciplines.

Section facilities at the Engineering and Research Center include several laboratories where various types of samples collected in the field are identified and analyzed.

A winter survey at Twin Lakes, Colorado. Studies are performed year-round to evaluate the effects of operation of Bureau projects on lake and reservoir ecosystems.

There is a fishery research laboratory, where fish tolerance to saline water, herbicides, and heavy metals is studied. The Section has a greenhouse complex where the effects of herbicides on a variety of aquatic weeds are tested.

Most of the work done by Section personnel occurs in the field – at reservoirs, canals, and streams. The Section is equipped with a number of boats and a wide variety of sampling and testing equipment to perform many types of aquatic evaluations effectively.

C. Activities

Environmental Sciences Section research programs gather and report information on many aspects of the aquatic environment to provide sufficient environmental data to reduce or minimize the effects of water development projects on the environment.

The Environmental Sciences Section conducts lake and reservoir studies before, during, and after construction

Environmental Sciences Section personnel investigate and provide solutions for restrictions to the flow of irrigation water caused by dense growths of aquatic weeds like hydrilla.

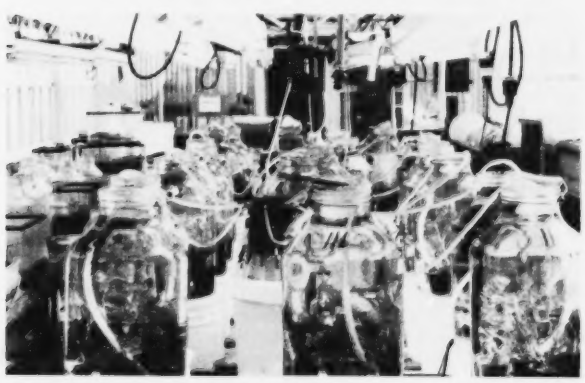
A Hypalon rubber liner in a lateral canal in California's Imperial Irrigation District prevents the growth of hydrilla and other flow-restricting vegetation.

of projects affecting these bodies of water. An example is work being performed on the Central Arizona Project. A study of the effects of pumping water out of Lake Havasu, located on the lower Colorado River, is being done to determine changes in the ecology of the lake. Other projects investigate the effects of the operation of pumped-storage powerplants on the ecosystems of Twin Lakes, Colorado, and Lake Mead, Arizona-Nevada.

River studies also constitute a major part of the Section's research. The ecology of regulated streams and tailwater habitats are currently being studied. The Environmental Sciences Section is conducting research on nitrogen supersaturation problems which can cause gas bubble

disease in game fish in the Bighorn River below Yellowtail Dam, Montana. An aquatic study on the lower Colorado River below Parker Dam, Arizona, is being conducted to compare the fish habitat differences between the dredged and riprapped upper section of the river with the unmodified lower section, for which similar modifications are proposed.

Canal studies focus on the problems of restricted waterflow caused by the growth of aquatic weeds in unlined canals. Some of these studies are performed in cooperation with the TVA (Tennessee Valley Authority) and the U.S. Army Corps of Engineers. The Environmental Sciences Section investigates the problems and recommends one or more of the three basic methods of removing vegetative overgrowth: (1) chemical treatment (herbicides), (2) mechanical removal (dredging and chaining), and (3) biological control (e.g., plant-eating fish). A recent study recommended the use of sterile grass carp to control the aquatic weed *Hydrilla*



Herbicides are tested on various aquatic weeds. The circulating pump shown above distributes fresh water to twelve test jars.

Biological methods of maintaining unrestricted flow in canals includes stocking fish species that feed on problem vegetation. Food preferences of hybrid grass carp are studied in the laboratory.

verticillata in irrigation canals in the Imperial Valley, where registered herbicides had proved ineffective. Another study indicated that grass carp have effectively controlled weeds in the South Platte Supply Canal, which irrigates farmland north of Denver.

Although the Environmental Sciences Section mainly does research related to aquatic environments, it also conducts terrestrial studies. Some of these are performed in conjunction with the U.S. Fish and Wildlife Service. Terrestrial studies concentrate on the damage to hydraulic structures caused by burrowing mammals (e.g., gophers and badgers) and on the testing of terrestrial herbicides that kill weeds growing in ditches, on canal banks, and on adjacent rights-of-way.

Environmental Sciences Section activities include research on many of the biological problems that affect Bureau projects and/or the surrounding environment. A study is now being conducted on controlled-release herbicides in Banks Lake, Washington. An herbicide designed to control Eurasian watermilfoil is being incor-

porated in a starch matrix material and allowed to release gradually when it is submersed. Both the herbicide and the starch matrix have been tested in the laboratory at the E&R Center and are currently being tested in the field.

Personnel of the Environmental Sciences Section perform many laboratory procedures to support its functions. Two major types of laboratory procedures are: (1) sample processing, in which biological and/or water-quality samples collected at field-study locations are analyzed; and (2) herbicide residue studies, in which new materials and methods are evaluated for specific applications.

III. THE CHEMISTRY, PETROGRAPHY, AND CHEMICAL ENGINEERING SECTION

A. Function

This section consists of three separate laboratories, which have responsibilities in well-defined but related areas. Through their research programs, these laboratories provide the Bureau with valuable information on the chemistry of construction materials, the molecular composition of earth materials, and the engineering uses of chemical reactions.

The Chemistry Laboratory performs water-quality investigations and chemical analyses of a wide variety of substances. The Petrography Laboratory evaluates soils, concrete, riprap, and rockfill materials; describes and classifies foundation rock; performs failure analyses on materials from construction materials. The Chemical Engineering Laboratory analyzes proposed desalting

Chemistry Laboratory personnel use basic and sophisticated equipment to provide a wide range of services.

projects, suggests solutions to water-quality problems, builds pilot plants, and directs research pilot programs for water-quality improvement and alternative energy processes.

B. Facilities and Capabilities

Each of the three laboratories in this section has its own highly qualified staff and both the basic and sophisticated equipment to provide a wide range of services.

The Chemistry Laboratory uses the following equipment:

- An atomic absorption spectroscope for trace metal analyses and for cation analyses of cements and pozzolans.

- An ion chromatograph for cation and anion analyses of chloride, sulfate, calcium, flouride, and bromide ions in solution.

- A GC/MS (gas chromatography/mass spectrometer), a high-resolution instrument used for identifying organic compounds in water, in biological organisms, and in construction materials.

- Infrared equipment for analyzing paints on USBR structures.

Petrography is the branch of geology that deals with the description and classification of rocks by microscopic examination of thin sections. The special facilities of the Petrography Laboratory include the following:

- Petrographic, steroscopic, and reflected-light microscopes, which identify and classify minerals and rocks, study the physical features of construction materials, and detect the constituents of concrete, respectively.

- A scanning electron microscope, which uses electron beams to highly magnify construction materials for identification.

- An X-ray diffractometer and X-ray spectrometer, which use X-ray beams to detect, identify, and measure the crystalline compounds and the elements in construction materials.

- A differential thermal analyzer, which uses heat and chemical reactions to detect, identify, and measure various characteristics of construction materials.

- An air-void ratiometer, which measures the entrained air in hardened concrete for the evaluation of air-entraining agents and freeze-thaw durability.

The facilities of the Chemical Engineering Laboratory fall into two categories: mobile, trailer-mounted equipment, which can be moved between field sites; and bench-scale and pilot-plant laboratories at the E&R Center.

Stereomicroscopes use non-polarized light to magnify physical features for the study of engineering materials.

The mobile equipment is used for pretreatment and desalting studies at the actual site of the waters being evaluated. The trailer transports equipment for lime and soda softening, ion-exchange softening, sand filtration, hydrogen sulfide stripping, reverse osmosis desalting, electrodialysis desalting, and ultrafiltration.

The bench-scale facilities at the E&R Center are designed for the concept work needed before a pilot-scale study. If bench-scale work is promising, research can be continued on a larger scale in either the pilot-plant laboratory in building 56 or the mobile field-test units.

The pilot-plant laboratory has 5,000 ft^3 of space and a water storage capacity of 1,600 gallons. Each of its four bays is equipped with electricity, water supply, water discharge facilities, and hook-up with a central computer. The pilot-plant laboratory also has two permanent reverse osmosis units with variable-volume pumps having capacities of 1,200 lb/in^2 at 8.5 gal/min flow.

C. Activities

The Chemistry Laboratory has investigated the salinity of the Colorado River for quite some time. Numerous research projects have focused on the measurement, the effects, and the reduction of salt in the Colorado River Basin. Another significant activity of the Chemisty Laboratory involves investigation of the effects of acid rain on the water quality of Bureau watersheds.

Recent projects performed by the Chemistry Laboratory includes Selenium Removal from San Luis Drain, California; Analysis of Samples from San Luis Drain for Organics Using Mass Spectrometry; Removal of Waste Formaldehyde from Water, Yuma Desalting Plant, Arizona; Chemical Methods for Evaluating the Bioavailability of Trace Metals; and Ground Water Chemistry.

A mobile test facility at LaVerkin Springs, Utah, a tributary of the Colorado River.

The Petrography Laboratory identifies, classifies, and evaluates a wide variety of construction materials. Recent projects include studies on:

- Soils–at New Waddell Damsite, Kennewick Main Canal, Bear Creek Pumping Plant, and Jordanelle Damsite.

- Foundation Rock–at Hoover Dam, Taskeech Damsite, Stewart Mountain Dam, and Coolidge Dam.

- Concrete–At Stewart Mountain Dam.

- Concrete Aggregate–at Pactola Dam, Davis Creek Dam, Taskeech Damsite, Moses Lake Area, Tucson Aqueduct, and Heart Butte Dam.

- Riprap–at New Waddell Damsite and Watkins Damsite.

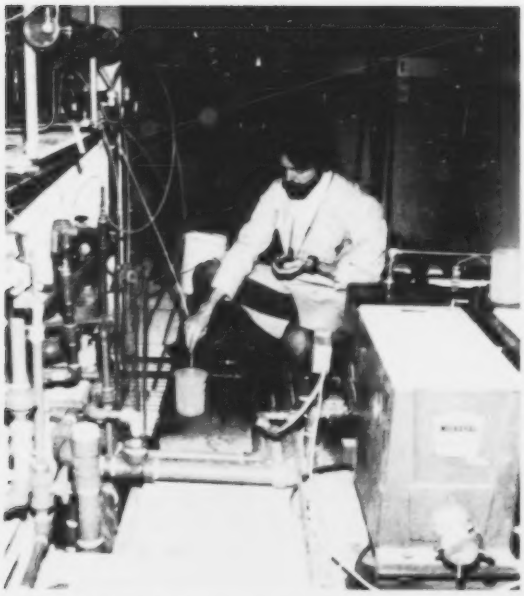
Much of the work of the Chemical Engineering Laboratory involves research on the salinity of the Colorado River. Investigations of the water quality in the Upper Colorado River Basin and of the effects of the Yuma Desalting Plant, in Arizona, constitute much of the staff's efforts.

Some recent projects include:

- Colorado River Water Quality Projects–a study of the use of saline water for powerplant cooling.

- Yuma Desalting Plant, Arizona, Title I–research to develop methods to prevent the deterioration of membrane filters and techniques for long-term membrane storage; also, pilot-plant studies on formaldehyde removal.

Mobile trailers are well-equipped for field activities.



The pilot plant laboratory at the E&R Center is used to conduct controlled tests.

- San Luis Drain, Central Valley Project, California–pilot studies on selenium removal.

- Advanced Energy Applications at El Paso, Texas–studies of solar ponds for desalting and power production.

- Saudi Arabia Research, Development, and Training Center–design and procurement of a laboratory, pilot plant, and training equipment for an overseas foreign activity project.

IV. THE MATERIALS SCIENCE SECTION

A. Function

The Materials Science Section studies construction materials and provides information on these materials to enhance Bureau design, construction, and O&M activities. This section tests a wide variety of construction materials, including polymers, metals, paints, concrete-curing compounds, joint sealers, roofing materials, plastic pipe, flexible-membrane linings, and geotextiles.

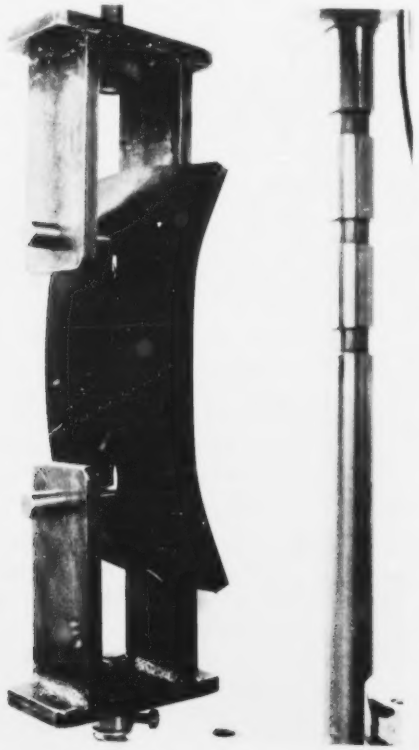
The Materials Science Section staff keeps abreast of current developments in the ever-changing construction materials industry so that the USBR can continue to use the best materials available. In fact, Materials Science Section personnel help develop the construction material standards of such influential societies as ASTM (American Society for Testing and Materials), AWWA (American Water Works Association), NSF (National Sanitation Foundation), ASAE (American Society of Agricultural Engineers), ACI (American Concrete Institute), USCOLD (United States Committee on Large Dams), and NACE (National Association of Corrosion Engineers).

B. Facilities and Capabilities

The Materials Science Section has the professional expertise and the facilities necessary to effectively test the physical properties of many construction materials. These tests are conducted in accordance with appropriate FSTM's (Federal Standard Test Methods) and ASTM methods.

The special facilities of the section include the following:

- An Automated Hydrostatic Test Facility for pressure-testing flexible membrane linings over various subgrades and under different operating conditions.



A bolt-hole shear test of a fabric-reinforced rubber waterproofing membrane.

- An Instron 1123 testing machine for determining the tensile and tear properties of flexible membrane linings and geotextiles.

- A Venturi-type cavitation apparatus for evaluating protective coatings.

- A static dead-load test apparatus for evaluating seam strength of flexible membrane linings.

- An apparatus for determining the compatibility of metal alloys in combination.

C. Activities

In its continuing effort to ensure that the Bureau uses only the most cost-effective materials, the Materials Science Section evaluates many construction materials.

The Section conducts studies to develop effective and economical methods of erosion control, soil stabilization, and seepage control. A study entitled, "Seepage and Erosion Control Materials," evaluates the performance of flexible membrane linings for canals and reservoirs. It also develops new laboratory tests and equipment to evaluate these materials.

Also under "Seepage and Erosion Control Materials," laboratory and field research studies are conducted on spray-on chemicals used to control erosion. Nontoxic, polymeric chemicals are sprayed on various types of slopes by a hydroseeder or other agricultural type spray rig. With evaporation, the residual material binds the particles to resist water and wind erosion. Research on spray-on erosion control has been coordinated with the U.S./U.S.S.R. joint study on "Plastic Films and Soil Stabilizers."

Corrosion control is an area of growing importance to the Bureau. Loss of mass and deterioration of the properties of construction metals are a problem. Therefore, the Materials Science Section researches corrosion control and corrosion prevention and provides technical assistance at the design, construction, and O&M phases of Bureau work.

Recent research on corrosion has concentrated on three areas: (1) identification of economical protection methods and materials for buried structures, (2) evaluation of the performance histories of pipe materials, and (3) familiarization with photovoltaic power supplies for new cathodic-protection systems.

The study, "Corrosion Control Methods and Materials," identified common corrosion problems; evaluated conditions and test methods; and studied various protection methods for buried pipelines and structures.

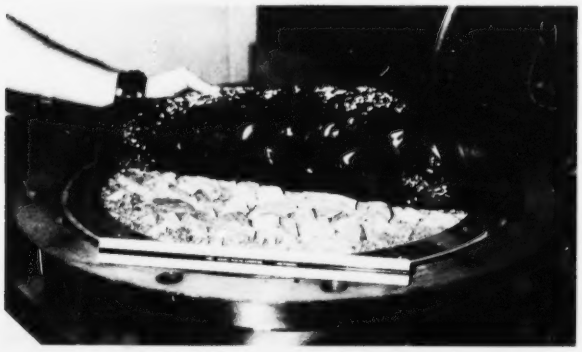
The Materials Science Section also conducts studies to identify effective and economical materials for canal

Application of spray-on soil stabilizer for soil erosion control on Southern Nevada Water Project.

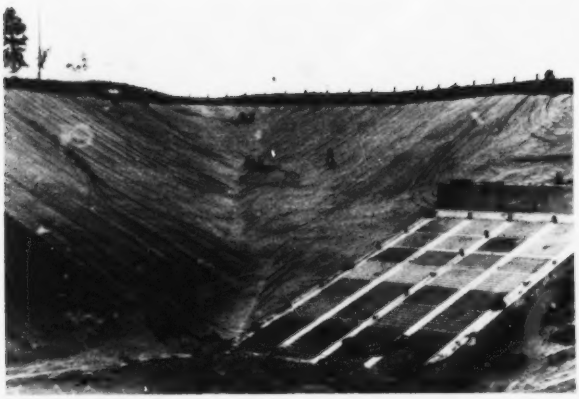
sealants. These sealants are used to minimize leakage through construction joints and through random cracks in concrete canal linings.

Although polysulfide sealants have been used effectively for several years, less costly materials, such as polyurethanes and hot-applied, coal-tar PVC sealants, are being evaluated. The study "Elastomeric Sealants for Joints in Concrete Structures" along with other investigations, are evaluating the performances of sealants under various conditions. The many sealant characteristics under scrutiny include physical properties, such as bond, tensile, and elastomeric properties; resistance to hydrostatic pressure; resistance to deterioration by water, weather, and heat; resiliency; hardness; and resistance to penetration.

The study entitled, "Plastic Pipe and Tubing Research," is evaluating new types of plastic pipe and tubing for use where the conventional steel, concrete, and asbestos



A flexible membrane after a test for puncture resistance over coarse rock. Flexible-membrane linings are used for seepage control in reservoirs and canals.



Installation of flexible-membrane lining for seepage control in Mt. Elbert Forebay Reservoir, Fryingpan-Arkansas Project, Colorado.

cement pipes are now installed. Plastics have a number of properties that make them desirable pipe materials: high strength-to-weight ratio, corrosion resistance, long service life, low heat transfer, impact resistance, flexibility, color adaptability, and low cost. The Materials Science Section is currently testing various plastic pipes, tubing, and joining sytems and working with manufacturers and the AWWA to develop standards and specifications.

The Materials Science Section is responsible for the quality-control testing and the approval or rejection of a variety of construction materials on all Bureau projects. These materials include those involved in the studies mentioned above, protective coatings and paints, plastic waterstops, thermal insulations for roofing, concrete-curing compounds, geotextiles, polyethylene drain tubing, and others.

V. THE REMOTE SENSING SECTION

A. Function

Through the use of cameras, radar, and optical-mechanical scanners on airplanes and satellites, the Remote Sensing Section provides valuable information on the earth's environment. This information is used by the Bureau in its planning, resource management, and operation and maintenance activities in many varied applications.

Remote Sensing Section personnel identify and map features of the environment important to Bureau programs. They provide information on the quantity and quality of water in reservoirs, conditions of vegetation and wildlife habitat, differences in surface soils, geologic structures (faults, joints, and folds), meteorological conditions, and other pertinent aspects of the environment.

B. Facilities and Capabilities

Remote sensing allows data to be gathered and transmitted quickly and inexpensively. This relatively new technology is a powerful tool, which can help us learn about many aspects of our environment more thoroughly than ever before.

The Remote Sensing Section is staffed by specialized analysts, each of whom is skilled in one or more of the many disciplines associated with Bureau projects. These analysts study earth features by interpreting images relayed from airborne and spaceborne sensors.

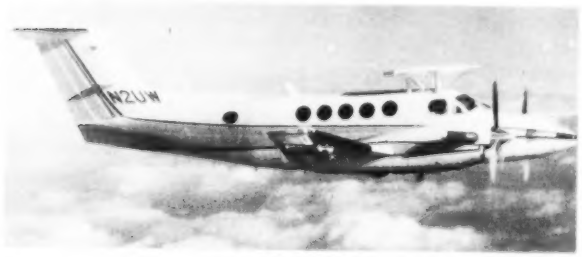
Although aerial photographs are still its primary source of data, some of the work of the Remote Sensing Section involves a much newer technology. Multispectral

scanners and thematic mappers onboard the Landsat satellite produce data digitally on computer-compatible tapes and analysts can generate photo-like images on film. Each earth feature reflects or emits a unique pattern of light, which creates a unique "spectral signature." The scanner and mapper sense these signatures and transmit images to analysts for use on Bureau projects.

One of the most valuable information gathering tools used by the Remote Sensing Section is an IDIAS (Interactive Digital Image Analysis System). This system consists of a color-image display device and fully integrated computer hardware and software. With digital imagery acquired from aircraft or spacecraft, analysts use this system to display images in true or false color or in black and white; to perform many image-enhancement programs; to overlay images with geographic boundaries, topography, and other data; and to classify and inventory features of interest within images.

C. Activities

The many activities of the Remote Sensing Section range from interpretation of aerial photographs and satellite



Airborne remote sensing systems provide images that supply information inaccessible from the ground.

An aerial photograph of Grand Coulee Dam in eastern Washington. Aerial photographs help Bureau personnel identify earth features such as vegetation, geology, and water resources.

imagery for resource inventories to sophisticated computer-aided analyses of geographic features. Some studies gather data about environments to be affected by Bureau projects. Other studies are performed after construction to improve operation and maintenance. These studies may monitor reservoir quality, check for leakage along canal structures, or evaluate sites for recreation development. Still other studies map irrigated lands for water management, locate distributions of noxious weeds for their control, and analyze cloud conditions for seeding to increase precipitation.

Some of the more significant recent and ongoing activities of the Remote Sensing Section are briefly described below.

- Garrison Land Resources Inventory: Aerial photography and mapping of nearly 9.5 million acres of land in various locations of the Garrison Diversion Unit in North Dakota, for Construction, environmental planning, and inventory of mitigation lands.

- National Wildlife Refuge Monitoring Program: Aerial photography and mapping of three National Wildlife Refuges and one State Game Management Area to gather information on the vegetation along the James River, North Dakota, before the return flow from the Garrison Diversion Unit changes conditions.

- Newlands Project Digital Geographic Data Base: Establishing digital geographic data that will allow midseason adjustments in irrigation water deliveries to the Truckee-Carson Irrigation District, Nevada.

- Sandhill Crane Roosting Habitat Study – Prairie Bend: Night thermal imagery for locating preferred

Satellite (Landsat) image of the Grand Valley Project in western Colorado used to monitor irrigation activity and wildlife habitat.

The Remote Sensing Section uses a computer system (IDIAS) to process digital imagery.

roosting sites and the distribution of sandhill cranes on the Platte River, in Nebraska, to estimate the effects of the proposed Narrows Dam.

- New Rockford (Garrison Diversion Unit) Area – Land Classification: Digitizing and measuring acreage of detailed land classification drawings to establish permanent digital records.

- Lake Havasu Limnology: Producing water-quality maps using imagery acquired by the Landsat 5 thematic mapper.

- Lower Gunnison Basin Unit: Color infrared aerial photography and mapping at 1:12,000 scale to monitor the effects of salinity-control construction on wildlife habitat.

- Water Quality – Flaming Gorge Reservoir: Studying the algae in the reservoir from color-coded water-quality images made from digital data acquired by satellite.

- Valley Center Irrigation District: Color photographs and satellite imagery to provide geographic data for surveys of irrigated lands.

GPO 849-171

NOTES

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.